

This listing of claims will replace all prior versions,
and listings, of claims in the application:

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1 Claim 1 (original): Apparatus for use in a mobile user
2 unit in an orthogonal frequency division multiplexing
3 (OFDM) based spread spectrum multiple access wireless
4 system comprising:
5 a receiver for receiving one or more pilot tone
6 hopping sequences each including pilot tones, said pilot
7 tones each being generated at a prescribed frequency and
8 time instants in a prescribed time-frequency grid; and
9 a detector, responsive to said one or more received
10 pilot tone hopping sequences, for detecting the received
11 pilot tone hopping sequence having strongest power.

1 Claim 2 (original): The invention as defined in claim 1
2 wherein each of said one or more pilot tone hopping
3 sequences is a Latin Squares based pilot tone hopping
4 sequence.

1 Claim 3 (original): The invention as defined in claim 1
2 wherein said receiver yields a baseband version of a
3 received signal and further including a unit for generating
4 a fast Fourier transform version of said baseband signal,
5 and wherein said detector is supplied with said fast
6 Fourier transform version of said baseband signal to
7 determine a received pilot tone sequence having the
8 strongest power.

1 Claim 4 (original): The invention as defined in claim 3
2 wherein said receiver further includes a quantizer for
3 quantizing the results of said fast Fourier transform.

1 Claim 5 (original): The invention as defined in claim 3
2 wherein said detector is a maximum energy detector.

1 Claim 6 (original): The invention as defined in claim 5
2 wherein said maximum energy detector determines a slope and
3 initial frequency shift of pilot tones in a detected pilot
4 tone hopping sequence having the strongest power.

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1 Claim 7 (original): The invention as defined in claim 6
2 wherein said maximum energy detector includes a slope-shift
3 accumulator for accumulating energy along each possible
4 slope and initial frequency shift of said one or more
5 received pilot tone hopping sequences and generating an
6 accumulated energy signal, a frequency shift accumulator
7 supplied with said accumulated energy signal for
8 accumulating energy along pilot frequency shifts of said
9 one or more received pilot tone hopping sequences, and a
10 maximum detector supplied with an output from said
11 frequency shift accumulator for estimating a slope and
12 initial frequency shift of the strongest received pilot
13 tone hopping sequence as a slope and initial frequency
14 shift corresponding to the strongest accumulated energy.

1 Claim 8 (original): The invention as defined in claim 7
2 wherein said accumulated energy is represented by the

3 signal $J_0(s, b_0)$, where $J_0(s, b_0) = \sum_{t=0}^{N_s-1} |Y(t, st + b_0 \pmod{N})|^2$, and s is
 4 the slope of the pilot signal, b_0 is an initial frequency
 5 shift of the pilot signal, $Y(t, n)$ is the fast Fourier
 6 transform data, $t = 0, \dots, N_s - 1$, $n = st + b_0 \pmod{N}$, and $n =$
 7 $0, \dots, N - 1$.

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 1 Claim 9 (original): The invention as defined in claim 7
 2 wherein said frequency shift accumulator
 3 accumulates energy along pilot frequency shifts of said one
 4 or more received pilot tone hopping sequences in accordance
 5 with $J(s, b_0) = \sum_{j=1}^{N_p} J_0(s, b_0 + n_j)$, where s is the slope of the pilot
 6 signal, b_0 is an initial frequency shift of the pilot signal
 7 and n_j are frequency offsets.

1 Claim 10 (original): The invention as defined in claim 7
 2 wherein said maximum detector estimates said slope and
 3 initial frequency shift of the strongest received pilot
 4 tone hopping sequence in accordance with $\hat{s}, \hat{b}_0 = \arg \max_{s, b_0} J(s, b_0)$,
 5 where \hat{s} is the estimate of the slope, \hat{b}_0 is the estimate of
 6 the initial frequency shift, and where the maximum is taken
 7 over $s \in S$ and $b_0 = 0, \dots, N - 1$.

1 Claim 11 (original): The invention as defined in claim 6
 2 wherein said maximum energy detector includes a frequency
 3 shift detector for estimating at a given time frequency
 4 shift of the received pilot tone hopping sequence having

5 strongest energy and an estimated maximum energy value, and
 6 a slope and frequency shift solver, responsive to said
 7 estimated frequency shift and said estimated maximum energy
 8 value, for generating estimates of an estimated slope and
 9 an estimated initial frequency shift of the strongest
 10 received pilot signal.

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 1 Claim 12 (original): The invention as defined in claim 11
 2 wherein said estimated frequency shift at time t is
 3 obtained in accordance with $n(t) = st + b_0 \pmod{N}$, where s is the
 4 pilot signal slope, t is a symbol time and $n(t)$ is a
 5 frequency shift estimate.

1 Claim 13 (original): The invention as defined in claim 12
 2 wherein said estimated maximum energy value is obtained in
 3 accordance with $[E(t), n(t)] = \max_n \sum_{j=1}^{N_p} |Y(t, n + n_j \pmod{N})|^2$, where $E(t)$
 4 is the maximum energy value, $Y(t, n)$ is the fast Fourier
 5 transform data, $j = 1, \dots, N_p$ and n_j are frequency offsets.

1 Claim 14 (original): The invention as defined in claim 13
 2 wherein said slope is estimated in accordance with

3 $\hat{s} = \arg \max_{s \in S} \sum_{t=1}^{N_{sy}-1} E(t) \mathbf{1}_{\{n(t) - n(t-1) = s\}}$, where both $n(t)$ and $n(t-1)$
 4 satisfy $n(t) = st + b_0 \pmod{N}$.

1 Claim 15 (original): The invention as defined in claim 13
 2 wherein said frequency shift is estimated in accordance

3 with $\hat{b}_0 = \arg \max_{b_0=0, \dots, N-1} \sum_{t=0}^{N-1} E(t) \mathbf{1}_{\{n(t)=M+b_0\}}$.

1 Claim 16 (original): The invention as defined in claim 11
 2 wherein said maximum energy detector detects said slope in
 3 accordance with determining the time, $t_0 \in T$, and slope, $s_0 \in S$,
 4 such that the set of times t on the line $n(t) = n(t_0) + s_0(t - t_0)$,
 5 has the largest total pilot signal energy.

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1 Claim 17 (original): A method for use in a mobile user
 2 unit in an orthogonal frequency division multiplexing
 3 (OFDM) based spread spectrum multiple access wireless
 4 system comprising the steps of:
 5 receiving one or more pilot tone hopping sequences
 6 each including pilot tones, said pilot tones each being
 7 generated at a prescribed frequency and time instants in a
 8 prescribed time-frequency grid; and
 9 in response to said one or more received pilot tone
 10 hopping sequences, detecting the received pilot tone
 11 hopping sequence having strongest power.

1 Claim 18 (original): The method as defined in claim 17
 2 wherein each of said one or more pilot tone hopping
 3 sequences is a Latin Squares based pilot tone hopping
 4 sequence.

1 Claim 19 (original): The method as defined in claim 17
 2 wherein said step of receiving yields a baseband version of

3 a received signal and further including a step of
4 generating a fast Fourier transform version of said
5 baseband signal, and wherein said step of detecting is
6 responsive to said fast Fourier transform version of said
7 baseband signal for determining a received pilot tone
8 sequence having the strongest power.

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1 Claim 20 (original): The method as defined in claim 19
2 wherein said step of receiving further includes a step of
3 quantizing the results of said fast Fourier transform.

1 Claim 21 (original): The method as defined in claim 19
2 wherein said step of detecting detects a maximum energy.

1 Claim 22 (original): The method as defined in claim 21
2 wherein said step of detecting said maximum energy includes
3 a step of determining a slope and initial frequency shift
4 of pilot tones in a detected pilot tone hopping sequence
5 having the strongest power.

1 Claim 23 (original): The method as defined in claim 22
2 wherein said step of detecting said maximum energy includes
3 steps of accumulating energy along each possible slope and
4 initial frequency shift of said one or more received pilot
5 tone hopping sequences and generating an accumulated energy
6 signal, in response to said accumulated energy signal,
7 accumulating energy along pilot frequency shifts of said
8 one or more received pilot tone hopping sequences, and in
9 response to an output from said step of frequency shift
10 accumulating, estimating a slope and initial frequency

11 shift of the strongest received pilot tone hopping sequence
 12 as a slope and initial frequency shift corresponding to the
 13 strongest accumulated energy.

1 Claim 24 (original): The method as defined in claim 23
 2 wherein said accumulated energy is represented by the
 3 signal $J_0(s, b_0)$, where $J_0(s, b_0) = \sum_{t=0}^{N_s-1} |Y(t, st + b_0 \pmod{N})|^2$, and s is
 4 the slope of the pilot signal, b_0 is an initial frequency
 5 shift of the pilot signal, $Y(t, n)$ is the fast Fourier
 6 transform data, $t = 0, \dots, N_s - 1$, $n = st + b_0 \pmod{N}$, and $n =$
 7 $0, \dots, N-1$.

1 Claim 25 (original): The method as defined in claim 23
 2 wherein said step of frequency shift accumulating includes
 3 a step of accumulating energy along pilot frequency shifts
 4 of said one or more received pilot tone hopping sequences
 5 in accordance with $J(s, b_0) = \sum_{j=1}^{N_f} J_0(s, b_0 + n_j)$, where s is the slope
 6 of the pilot signal, b_0 is an initial frequency shift of the
 7 pilot signal and n_j are frequency offsets.

1 Claim 26 (original): The method as defined in claim 23
 2 wherein said step of maximum energy detecting includes a
 3 step of estimating said slope and initial frequency shift
 4 of the strongest received pilot tone hopping sequence in
 5 accordance with $\hat{s}, \hat{b}_0 = \arg \max_{s, b_0} J(s, b_0)$, where \hat{s} is the estimate of
 6 the slope, \hat{b}_0 is the estimate of the initial frequency

7 shift, and where the maximum is taken over
8 $s \in S$ and $b_0 = 0, \dots, N-1$.

1 Claim 27 (original): The method as defined in claim 22
2 wherein said step of maximum energy detecting includes a
3 step of estimating at a given time frequency shift of the
4 received pilot tone hopping sequence having strongest
5 energy and estimating a maximum energy value, and in
6 response to said estimated frequency shift and said
7 estimated maximum energy value, generating estimates of an
8 estimated slope and an estimated initial frequency shift of
9 the strongest received pilot signal.

1 Claim 28 (original): The method as defined in claim 27
2 wherein said estimated frequency shift at time t is
3 obtained in accordance with $n(t) = st + b_0 \pmod{N}$, where s is the
4 pilot signal slope, t is a symbol time and $n(t)$ is a
5 frequency shift estimate.

1 Claim 29 (original): The method as defined in claim 28
2 wherein said estimated maximum energy value is obtained in
3 accordance with $[E(t), n(t)] = \max_n \sum_{j=1}^{N_p} |Y(t, n + n_j \pmod{N})|^2$, where $E(t)$
4 is the maximum energy value, $Y(t, n)$ is the fast Fourier
5 transform data, $j = 1, \dots, N_p$ and n_j are frequency offsets.

1 Claim 30 (original): The method as defined in claim 29
2 wherein said slope is estimated in accordance with

- 3 $\hat{s} = \arg \max_{s \in S} \sum_{t=1}^{N_{sy}-1} E(t) 1_{\{n(t)-n(t-1)=s\}}$, where both $n(t)$ and $n(t-1)$
- 4 satisfy $n(t) = st + b_0 \pmod{N}$.

1 Claim 31 (original): The method as defined in claim 29

2 wherein said frequency shift is estimated in accordance

- 3 with $\hat{b}_0 = \arg \max_{b_0=0, \dots, N-1} \sum_{t=0}^{N_{sy}-1} E(t) 1_{\{n(t)=b_0\}}$.

1 Claim 32 (original): The method as defined in claim 27

2 wherein said step of maximum energy detecting includes a

3 step of finding the time, $t_0 \in T$, and slope, $s_0 \in S$, such that

4 the set of times t on the line $n(t) = n(t_0) + s_0(t - t_0)$, has the

5 largest total pilot signal energy.

1 Claim 33 (original): Apparatus for use in a mobile user

2 unit in an orthogonal frequency division multiplexing

3 (OFDM) based spread spectrum multiple access wireless

4 system comprising the steps of:

- 5 means for receiving one or more pilot tone hopping
- 6 sequences each including pilot tones, said pilot tones each
- 7 being generated at a prescribed frequency and time instants
- 8 in a prescribed time-frequency grid; and
- 9 means, responsive to said one or more received pilot
- 10 tone hopping sequences, detecting the received pilot tone
- 11 hopping sequence having strongest power.

1 Claim 34 (original): The invention as defined in claim 33

2 wherein each of said one or more pilot tone hopping

3 sequences is a Latin Squares based pilot tone hopping
4 sequence.

1 Claim 35. (original): The invention as defined in claim 33
2 wherein said means for receiving yields a baseband version
3 of a received signal and further including means for
4 generating a fast Fourier transform version of said
5 baseband signal, and wherein said means for detecting is
6 responsive to said fast Fourier transform version of said
7 baseband signal for determining a received pilot tone
8 sequence having the strongest power.

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1 Claim 36 (original): The invention as defined in claim 35
2 wherein said means for generating said fast Fourier
3 transform includes means for quantizing the results of said
4 fast Fourier transform.

1 Claim 37 (original): The invention as defined in claim 35
2 wherein means for detecting detects a maximum energy.

1 Claim 38 (original): The invention as defined in claim 37
2 wherein said means for detecting said maximum energy
3 includes means for determining a slope and initial
4 frequency shift of pilot tones in a detected pilot tone
5 hopping sequence having the strongest power.

1 Claim 39 (original): The invention as defined in claim 38
2 wherein said means for detecting said maximum energy
3 includes means for accumulating energy along each possible
4 slope and initial frequency shift of said one or more

5 received pilot tone hopping sequences, means for generating
 6 an accumulated energy signal, means, responsive to said
 7 accumulated energy signal, for accumulating energy along
 8 pilot frequency shifts of said one or more received pilot
 9 tone hopping sequences, and means, responsive to an output
 10 from said means for frequency shift accumulating, for
 11 estimating a slope and initial frequency shift of the
 12 strongest received pilot tone hopping sequence as a slope
 13 and initial frequency shift corresponding to the strongest
 14 accumulated energy.

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 1 Claim 40 (original): The invention as defined in claim 39
 2 wherein said accumulated energy is represented by the
 3 signal $J_0(s, b_0)$, where $J_0(s, b_0) = \sum_{t=0}^{N_s-1} |Y(t, st + b_0 \pmod{N})|^2$, and s is
 4 the slope of the pilot signal, b_0 is an initial frequency
 5 shift of the pilot signal, $Y(t, n)$ is the fast Fourier
 6 transform data, $t = 0, \dots, N_s - 1$, $n = st + b_0 \pmod{N}$, and $n =$
 7 $0, \dots, N - 1$.

1 Claim 41 (original): The invention as defined in claim 39
 2 wherein said means for frequency shift accumulating
 3 includes means for accumulating energy along pilot
 4 frequency shifts of said one or more received pilot tone
 5 hopping sequences in accordance with $J(s, b_0) = \sum_{j=1}^{N_f} J_0(s, b_0 + n_j)$,
 6 where s is the slope of the pilot signal, b_0 is an initial
 7 frequency shift of the pilot signal and n_j are frequency
 8 offsets.

1 Claim 42 (original): The invention as defined in claim 39
 2 wherein said means for maximum energy detecting includes
 3 means for estimating said slope and initial frequency shift
 4 of the strongest received pilot tone hopping sequence in
 5 accordance with $\hat{s}, \hat{b}_0 = \arg \max_{s, b_0} J(s, b_0)$, where \hat{s} is the estimate of
 6 the slope, \hat{b}_0 is the estimate of the initial frequency
 7 shift, and where the maximum is taken over
 8 $s \in S$ and $b_0 = 0, \dots, N-1$.

1 Claim 43 (original): The invention as defined in claim 37
 2 wherein said means for maximum energy detecting includes
 3 means for estimating at a given time frequency shift of the
 4 received pilot tone hopping sequence having strongest
 5 energy and for estimating a maximum energy value, and
 6 means, responsive to said estimated frequency shift and
 7 said estimated maximum energy value, for generating
 8 estimates of an estimated slope and an estimated initial
 9 frequency shift of the strongest received pilot signal.

1 Claim 44 (original): The invention as defined in claim 43
 2 wherein said estimated frequency shift at time t is
 3 obtained in accordance with $n(t) = st + b_0 \pmod{N}$, where s is the
 4 pilot signal slope, t is a symbol time and $n(t)$ is a
 5 frequency shift estimate.

1 Claim 45 (original): The invention as defined in claim 44
 2 wherein said estimated maximum energy value is obtained in
 3 accordance with $[E(t), n(t)] = \max_n \sum_{j=1}^{N_f} |Y(t, n + n_j \pmod{N})|^2$, where $E(t)$

4 is the maximum energy value, $Y(t,n)$ is the fast Fourier
5 transform data, $j = 1, \dots, N_p$ and n_j are frequency offsets.

1 Claim 46 (original): The invention as defined in claim 45
2 wherein said slope is estimated in accordance with

3 $\hat{s} = \arg \max_{s \in S} \sum_{t=1}^{N_{sy}-1} E(t) \mathbf{1}_{\{n(t)-n(t-1)=s\}}$, where both $n(t)$ and $n(t-1)$

4 satisfy

1 $n(t) = st + b_0 \pmod{N}$.

1 Claim 47 (original): The invention as defined in claim 45
2 wherein said frequency shift is estimated in accordance

3 with $\hat{b}_0 = \arg \max_{b_0=0, \dots, N-1} \sum_{t=0}^{N_{sy}-1} E(t) \mathbf{1}_{\{n(t)=st+b_0\}}$.

1 Claim 48 (original): The invention as defined in claim 43
2 wherein said means for detecting maximum energy includes
3 means for finding the time, $t_0 \in T$, and slope, $s_0 \in S$, such that
4 the set of times t on the line $n(t) = n(t_0) + s_0(t - t_0)$, has the
5 largest total pilot signal energy.